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THREE COMMERCIALLY IMPORTANT POLYCHAETE

MARINE WORMS FROM MAINE:

Nereis (Neanthes) virens

Glycera dibranchiata

Glycera americana\*

BY

Philip E. Glidden

1951

\*Pratt in his Manual of the Common Invertebrate Animals does not list G. americana as found in Maine, but Sandroff (National Geographic Magazine, 1946) finds this species to be widespread in Maine.

## THE WORMING INDUSTRY OF MAINE

Ever since the Red Paint People roamed the irregular shoreline of Maine and contributed their culture to the history of Maine folklore, the great shell heaps left by these people and the Indians that followed them along the sheepscoot, Damariscotta and other Maine rivers now stand as a lasting monument to the richness and productivity of Maine waters. Since then these waters have given up their secrets in a long progression of fruitful discoveries. Perhaps the most unusual of them all was the discovery that the lowly marine worms that occur in countless thousands beneath the surface of Maine mud flats were a valuable commercial commodity. When the importance of marine worms was recognized by the Maine fisherman, he accepted the situation as an opportunist might and has been profiting by his discovery ever since. To the clam diggers in particular the great outside demand for marine worms as bait came as welcome news, because clam beds were being slowly exhausted, and many beds were closed to digging because of pollution and other causes. The new profession of worming was a perfect substitute for the condition in which these men found themselves when their supplies of clams began to dwindle. Worming is occupationally very similar to the profession of clam digging, and to readjust themselves to digging for marine worms the clam diggers had merely to provide themselves with a different shaped hoe and move to an area on the mud flats where there was a predominance of marine worms to dig. The digging of marine worms may be termed analogous to the harvesting of potatoes, for the mud flats are merely hoed back by turning over the top layer of mud thereby exposing the worms which are then picked up and placed in a bucket. The worms are then carried from the flats and placed in a cool cellar where they may be either stored for a time or shipped immediately to market. Hot weather is very detrimental to keeping large numbers of worms alive, and for this reason the valuable commodity

is shipped almost immediately after it has been harvested during the sultry months of July and August. Packed in moist seaweed after they have been carefully sorted, the worms are quickly shipped by express and even by plane to distant markets along the Atlantic coast from Maine to Florida.

Commercially important marine worms belong to the Phylum Annelida. They closely resemble the common earthworm but have become adapted to a salt water existence through various bodily modifications. Running in waves along their sides are curious paddle-like structures with which they propel themselves through the mud and sand of their habitats. An evasable mouthpart called the proboscis (which operates very much like a pile-driver) may be used as an extra appendage to enable them to burrow through the mud with amazing rapidity. Usually, however, they fashion a tube in the mud or sand which (in the case of Nereis virens) is lined with their own mucus secretions. At night they attach themselves posteriorly in their tube and stretch themselves out like the common garden night crawler in search of food. Commercially valuable worms are of two types: (1) the sandworm (Nereis virens). (2) The bloodworm which is in reality two distinct species, Glycera dibranchiata and Glycera americana. The sandworm is the largest and most numerous species, but is less highly valued by the worm fisherman. (Figs. 1 and 2) Nereis is a beautiful iridescent color with a flat, tapering body. Glycera lacks the iridescent hue and is conical rather than flat.

The worming industry in Maine probably began in the Portland Bay area in the early nineteen twenties. No one seems to know for sure just when marine worms were dug commercially for the first time, but for many years the worming profession was confined to Long Island and scattered areas along the New England coast. Originally fishermen caught marine worms for bait as they needed it. Ultimately, however, a great increase in demand from fishermen created the worming



industry as a profession. Later when the quest for this important fisheries product had exhausted local areas the great mud flats of Maine were discovered, and the exploitation began. It cannot be said, however, that the Maine worming industry was exceedingly local. Most respectable fishermen "looked down their noses" at the lowly worm. For years many clam diggers held the sandworm in great contempt, because they believed these worms were responsible for the destruction of a great many of their highly-valued clams. This belief has no foundation just as the belief, which is still held by some people, that the sandworm is the male clam is untrue. It is natural that these beliefs contributed to a certain skepticism toward the digging of marine worms, and in part was responsible for the slow growth of the industry in the twenties. Gradually, however, the increased demands for marine worms from Maine coupled with the depletion of clam flats brought about a change in the embryonic industry (which by the middle 1930's was well enough established to instigate control legislation in 1937).

Marine worms are always dug at low tide when hundreds of acres of mud flats are exposed along the Maine Coast to the hoe of the wormer. In the short period between tides the day's work of the worm digger is accomplished. The worm digger's life isn't as easy as it sounds, however, for his working hours are governed by the caprices of tides which are often very fickle. Sometimes two tides can be dug during the course of daylight, but most often one tide is the extent of his day's labors. Worming operations are not strictly confined to the daylight hours; some hardy souls hunt for worms at night when they are stretched out of their tubes in search of food. These snipers, as they are called locally, are the most rugged of the clan, and also the most dexterious. Carrying a powerful lamp which he straps to his forehead, the sniper creates an eerie picture as he starts off for his lone walk through the flats. The sniper catches his prey when

they are lying half-exposed from their tubes, but he must be quick and sure or the worm will escape deep within its protective tube.

The saga of worming is all the same whether it is done in the daylight or at night with a lamp. It is all back-breaking work; the mud sticks like tar and has the sickening odor of free sulphur. To be a worm digger a man must have extraordinary stamina, and most of all a philosophical toleration of his chosen profession. This is, perhaps, the great reason that worm fishermen usually dig alone - worming is a serious work and "the tides don't wait for any man." On the flats where every step creates a binding suction in the soft mud, the worm digger moves along in a gait that is characteristic of his profession. His high rubber boots are alternately thrust forward vertically into the mud and removed with a curious twist that breaks the suction easily. You can usually tell a worm fisherman in town.

#### INTRODUCTION AND CLASSIFICATION

1. In Maine there are three commercially important Polychaete worms that are commonly dug and sold as bait by worm fishermen: Nereis virens of the family Nereidae; Glycera dibranchiata and Glycera americana of the family Glyceridae. In this article the author has set forth the biology and natural history of the above species of Polychaete worms plus their commercial importance as a fisheries product of Maine waters.

2. Phylum - Annelida

Class - Chaetopoda

Order - Polychaeta

Family - Nereidae

Genus - Nereis

Species - Nereis (Neanthes) virens Sara\* (Fig. 1)

Family - Glyceridae

Genus - Glycera

Species - Glycera americana Leidy

Species - Glycera dibranchiata Ehlers (Fig. 2)

#### DISCRIPTION AND HABITAT

##### 1. Genus Nereidae

The large green Nereis virens is one of the most beautiful and brilliant of marine worms. The flat, tapered body is well adapted for life in the thick, sulphurous mud of its habitat. The sandworm is a swift predatory animal that seeks the darkness of its protective tube during the day, and the blackness of the night in which to seek its prey. It has been written of the Nereids: "The habits of some of the prettiest.... belie their lovely appearances; for they are not unfrequently those of the stage ruffian who struts about in garments which have been obtained by means of murder and robbery. Not a few of the errant, or wandering worms, live by stealthily preying on objects actually more highly organized than themselves."<sup>1</sup> This is indeed the case of Nereis virens, for underneath its iridescent dress rest two of the most formidable teeth in the animal kingdom. Rows of lateral paddle-like appendages drive this monster of the animal world swiftly through the mud making it even more formidable. The sandworm may reach a length of twenty inches or more, and several specimens have been recorded that have exceeded thirty inches. The average length of over seventy specimens measured by the author measured 9.7 inches.\*\* Verrill recorded the sandworm at Eastport as early as 1871<sup>2</sup>, and again in 1874<sup>3</sup> in sand and muddy sand close to the high water-mark. The observations agree with that of Flye as being the general habitat of

\* The term Neanthes has recently been substituted for the older name Nereis, but in this paper the older name will be used.

\*\*Pratt gives the length of Nereis virens at 30 cm.. width 1 cm.

Pratt, Henry S., A Manual of the Common Invertebrate Animals, Revised Edition, Philadelphia, The Blakiston Company. 1935. p. 336.

this species of Nereis along the Maine coast.<sup>4</sup> The author has found Nereis virens very active during the summer months; usually in greatest numbers at the high watermark and about ten inches beneath the surface of the sand. The largest worms, however, are found at a greater depth. Sexually mature worms (epitoke) are often seen swimming in the water from early spring through the summer months. Bumpus has seen them in quantity in Narragansett Bay (Massachusetts) during March.<sup>5</sup> Asexual (atoke) individuals remain beneath the surface during the day and only appear on the surface to forage during the evening. In winter the sandworm burrows into the mud and becomes inactive, but some may remain active all during the winter months.<sup>5</sup>

The history of the sandworm in the vicinity of Maine waters began in 1854 when it was recorded by Stimpson in the mud flats of Grand Manan Island in the Bay of Fundy as Nereis grandis.<sup>6</sup> Verrill identified Nereis grandis at Eastport in 1871 as being "very plentiful" in the mud and mud-sand flats of that area<sup>2</sup>. In a later report on the Casco Bay region of Maine, Verrill found Nereis virens very widespread over the entire area in mud flats, particularly at the low watermark. Again at Eastport, Webster and Benedict in 1887 found Nereis virens as being: "Very common. Low water, mud and sandy mud."<sup>8</sup> Since these first recordings of Nereis virens were made many more observations have clearly established the species as being the most common marine Annelid in Maine waters; there are few mud or mud-sand flats where the species cannot be found in relatively large numbers. Men who engage in the commercial digging of these worms agree that the sandworm is found in greatest abundance at the low watermark to several yards above. Webster and Benedict have found that in the Massachusetts Cape area Nereis virens may be found "between tides, ranging nearly to the top of high Water."<sup>9</sup> In Maine the species can be found almost anywhere between the tide levels. It is especially common in flats bordering the mouths of rivers,

## 2. Genus Glyceridae

The two commercial forms of Glycera, G. americana and G. dibranchiata, (Fig. 1) found in Maine waters are less commonly known than Nereis virens. Commercially they are grouped together under the term bloodworm, but in an examination of over two hundred worms from the flats of the Sheepscot and Yarmouth River districts by the author no specimens of Glycera americana were located, although Sandrof speaks of it as being numerous.<sup>10</sup>

G. dibranchiata and G. americana outwardly appear very much alike, but can be readily identified by the type and position of the branchae located on the parapoda (Fig. 4). They are long, smooth, cylindrical worms that are symmetrically tapered at both ends. The lateral appendages (parapoda) are much smaller than those of Nereis virens, and the reddish color gives them a striking resemblance to the common earthworm. The average size of seventy specimens measured by the author was approximately eight inches in length\*, but large individuals may reach a length of twenty-five inches or more. Instead of two teeth as in the case of the sandworm the proboscis of Glycera is armed with four curved hooks. In distribution bloodworms are far more littoral than Nereis virens, and unlike this species Glycera is found many miles from the ocean in the mud flats caused by the action of the tide. Hartman gives the range of Glycera americana as intertidal and that of Glycera dibranchiata as littoral<sup>11</sup>; but Andrews has recorded them both as inhabiting shoals in the Beaufort area of North Carolina.<sup>12</sup> According to Flye "sandworms are found much deeper than bloodworms. The digger must first remove the top layer of soft mud (about 5 inches deep) and then dig down about 10 inches further in the clay or sand before any quantity can be found."<sup>4</sup> Glycera dibranchiata was first recorded in Maine at Eastport by Verrill as Rhyn-

\*Pratt gives the length of Glycera dibranchiata and G. americana at 20 cm., and the width at about 4 mm.

Pratt, Henry S., A Manual of the Common Invertebrate Animals, Revised Edition, Philadelphia, The Blakiston Company, 1935, pp. 333-334.



chobolus dibranchiata (1873)<sup>3</sup>. Earlier he had found this species to be common in Massachusetts Bay from "low water to eight fathoms,"<sup>2</sup> and Webster had found it in considerable numbers in New Jersey waters "from low water to 15 feet."<sup>13</sup> That sand and bloodworms are seldom found together is a good illustration of their carnivorous temperaments, and for this and other reasons a terrestrial diagram can be drawn as to their local distribution (Dia.1).

Shore Line		
High Watermark		
1. Soft Shell Clam Beds ( <u>Mya arenaria</u> )	Predominate	
.....		
2. Bloodworms ( <u>Glycera</u> )	"	
.....		
3. Sandworms ( <u>Nereis virens</u> )	"	
Low Watermark		
4. Blue Mussels ( <u>Mytilus edulis</u> )	"	

Dia. 1. Distribution of four marine organisms in greatest proportion between the tide levels.

## ANATOMY

### A. General Characteristics:

The Polychaeta worms are among the most primitive of Annelids. They are metamerically segmented in a linear series of somites with a single differentiated segment at the anterior end and called the prostomium (Fig. 2). The true coelom is surrounded by outer circular and inner longitudinal muscle layers. The nervous system consists of a double ventral nerve cord from which a pair of ganglia radiates out to each segment. The brain is a double gangliated process of the nerve cord located in the preoral segment. Paired nephridial excretory organs are located ventrally in each segment (Figs. 6 and 7). Situated in rows along the lateral sides of the worm and corresponding to each segment are the paired parapoda upon which are situated numerous chitinous chaetae. The parapoda are paddle-like structures which are used to drive the worm through the mud. The prostomium is a highly modified caudal segment called the head. Upon it are situated the double sets of simple eyes; the prostomial tentacles and the double palps. The sexes are separate, and the larva is a free-swimming trochophore.<sup>14</sup>

### B. Genus Nereidae:

Nereis virens\* differs little from the general characteristics of the Polychaeta. It is a so-called errant Polychaete with an unmodified prostomium. This prostomium bears two kinds of modified parapoda, the dorsal tentacles and the thick ventral palps. The modified portion behind the prostomium is called the peristomium. Here parapoda are not present, but two pairs of cirri remain, the peristominal cirri. There are two pairs of eyes located on the prostomium. Arising at the anterior part of the digestive tube is an eversible proboscis

\*A good anatomy of Nereis virens may be found in Turnbull's Anatomy and Habits of Nereis virens, Conn. Acad. Arts Sci. Trans., Vol. 3, pp. 265-281, 1876.



which is terminated by two black, serrated teeth. Branched parapoda run in waves along each side of the worm. Each segment carries two parapoda which is divided into two distinct parts: the double ventral neuropodium which has a respiratory function and the dorsal notopodium which is also double. Both the neuropodium carry cirri and a number of setae. Each of these bundles of chaeta are supported by internal chaeta called the aciculum which forms the point of insertion for the muscles of the parapoda. Special cells (those of the hypodermis) secrete a protective outer layer called the cuticle. The coelom or body cavity is linearly divided by transverse septae which correspond to the segmentation of the body. The worm leads an active life and has a powerful eversible proboscis with which it tunnels through the mud. It often forms a protective tube in the mud and lines it with its own secretions. During the sexual period there is a great structural modification. This is the heteronereis stage of the epitoke sexually-mature males and females.<sup>15</sup>

Digestion. The alimentary canal of Nereis extends anteriorly as a pharynx which opens out as the mouth. The pharynx may be extended to form a proboscis controlled by strong muscles. Behind the pharynx is an elongated oesophagus extending posteriorly in the straight intestinal tract to the anus in the posterior terminal segment. The digestive process is entirely extracellular as in all the annelids.<sup>14</sup>

Circulation. The circulatory system is closed; all blood vessels are separated from the coelom by septa. It consists of a dorsal vessel which carries the blood caudad and a ventral vessel which carries the blood posteriorly. From each body segment arise two alimentary vessels that connect with the main artery. Peristaltic contractions of the dorsal vessel force the blood forward and backward through the intestinal sinus and ventral vessel.

Nervous system. The brain of Nereis is a super-oesophageal ganglion that is connected with two sub-oesophageal ganglia by two nerves which curve around the pharynx. A ventral nerve cord extends posteriorly from the brain. The nerve cord gives off a pair of nerves to each segment, and nerve fibers from the cord also serve to innervate the anterior tentacles of the prostomium. Several ganglia around the pharynx constitute the visceral nervous system.

Respiration. The parapoda aid in gaseous interchange. Hemoglobin in the blood allows the worm to make use of nearly all the oxygen available to it in the water, also this pigment allows the worm's blood to store more oxygen than it would otherwise be able to hold.

#### C. Genus Glyceridae

There are the so-called burrowing Polychaeta with a proboscis and a reduced prostomium. In general the prostomium is elongated and conical with small tentacles arising near its apex. Two retractile palps occur ventrally on each side of the prostomium. The parapoda are small and uniform throughout the body, but otherwise similar to Nereis. The protrusible proboscis is a very large and muscular organ, and is armed with four curved chitinous teeth. The proboscis bears distally numerous papillae and is adaptable much as in the case of Nereis. The reddish color of the skin is caused by the hemoglobin bearing blood which shows through the integument. This reddish color plus its rounded shape gives Glycera much the same appearance as the earthworm. The internal anatomy of Glycera is very similar to that of Nereis, the main difference being found in the nephridia and in Glycera having an open circulatory system which enables the blood and coelomic fluids to mix.

Both G. dibranchiata and G. americana are frequently found together, and because of their great similarity they are difficult to tell apart. Distinguishing the living specimens has to do with the erythrocytes that can be seen circulating

in the posterior branchiae of G. dibranchiata. In G. americana these are not visible. The branchiae of G. americana are retractable while those of G. dibranchiata are not. The branchiae of G. americana emerge on the posterior side of the parapoda at the level of the dorsal cirris, but the branchiae of G. dibranchiata have full-formed dorsal ventral lobes.<sup>16</sup> (Fig. 4)

## REPRODUCTION

### A. Uro-Genital System

The kidney of Glycera and Nereis is a segmented organ opening into the coelom. They are found in pairs in each of the segments except the peristomium and the anal segment. Each excretory organ is divided into a funnel-like nephridium opening inside the coelom (coelomoduct). The organs are used to carry waste products and sometimes gametes from the body cavity to the outside. In Nereis there is a ciliated funnel from each nephridium that opens into the coelomic cavity. It passes posteriorly through the septum into the following segment. Here it becomes formed into a convoluted tubule opening into a nephridiopore on the ventral surface at the base of the parapoda. Chamberlin asserts that the Glyceridae have nephridia "with inner end closed...."<sup>15</sup> but other authorities believe this closed position is merely a rudiment of the coelomoduct that has persisted in some cases in the Glyceridae.<sup>14</sup>

### B. Spawning

Nereis virens. The gonads are situated in the peritoneal epithelium of nearly all segments of the worm. When mature the gonads overfill the body cavity causing a pressure under which the gametes escape through the nephridiopores. The pressure is often so great so as to rupture the body of the worm permitting a free flow of gametes into the seawater.<sup>15</sup> This epitokous form is known more generally as the heteronereis stage, which is a metamorphosis from the ordinary asexual form

to the pelagic sexual life. The change to the heteronereis stage is one coupled with radical bodily changes. There is a great increase in the size of the eyes; the palpi are shortened, and the body becomes divided into two distinct parts.

"Of these the anterior, or so-called nereid division, which is comparatively short, retains parapodia of the ordinary form, while the posterior or heteronereid division has parapodia conspicuously modified. These commonly bear special foliaceous lobes and numerous large, special, natatory setae. The sexual products arise in the posterior division where they may remain, giving it a darker and more opaque appearance contrasting with the commonly colorless and often transparent anterior region, or the products in other cases crowd forward into all the somites. Between the epitokous male and female a sexual dimorphism exists which is often very striking."<sup>17</sup>

Liberating their eggs and sperm freely in the water as they do, the worms often exhibit a phenomenon known as swarming. This spectacle occurs when mature individuals rise to the surface swimming vigorously to exude their sexual products free into the water. In Maine sandworms spawn in the spring from the middle of March to late in June. An interesting observation of this phenomenon was made by Gray in the Woods Hole district: "On March 24, 1900, clamworms were seen swimming in the shallow water along the shore of Monamesset Island, near Sheep Pen Cove. Nearly 300 specimens were captured in an hour's time. As the tide rose the worms burrowed down in the sand, several being taken when the head and a portion of the body were hidden beneath the surface....although the greater number were of the characteristic olive-green color, some were dull yellowish-orange. After the worms were placed in a bucket they discharged their sexual products until the water looked like milk. On subsequent days only scattering individuals were taken."<sup>18</sup> The male and female sexually mature individuals in the above observation are described as being yellowish-orange, but Flye contends that the spawning worms are much redder than the above observation would indicate.<sup>4</sup> Turnbull however describes: "The body



in the male is an intense steel-blue, which blends into green at the base of the lateral appendages. In the female the body is of a dull greenish color, with a slight tinge of orange and red. The appendages are orange-green at the base, and become bright orange toward their extremities; but sometimes they are greenish throughout.<sup>19</sup> At the time of spawning there is a general irritation of the epithelium and musculature of the worms. Usually these grown individuals are nearly transparent and the gonadial products can be easily seen with the naked eye.<sup>20</sup> When the temperature of the water is agreeable the worms disgorge their sexual products free in the water. The worms become ruptured or constrict off the posterior parts of their bodies allowing the sperm and eggs to be set free, and exhausted by the ordeal of spawning they die and become prey for the carrion-eaters.

Glycera. According to Moore Glycera dibranchiata in the Woods Hole district "Breeds during the summer but ripe individuals are seldom met with (not true in Nereis virens). Epitokous individuals are very rare."<sup>21</sup> The ripe individuals shed their sperm free in the water whereas in Nereis where fertilization takes place their greatest spawning period is at night during the absence of the moon. The author has taken numbers of ripe individuals in the Boothbay - Wiscasset area at night during August. These are usually of a brownish tint; the gonadial products are entirely loose within the worm's body. The spawning habits of Glycera americana are much the same as in the above species. In the Woods Hole district Moore has recorded it as "Rarely taken at night swimming at the surface. Such epitokous individuals are sexually mature and have the setae longer and more numerous and spreading. Habits similar to those of Glycera dibranchiata. It twists itself rapidly into the sand with a whirling motion like a cork-screw. Breeds throughout the summer, but fully mature individuals are most frequent in August in both the atokous and epitokous state."<sup>21</sup> The larvae of both species is planktonic, and last for as long as several weeks or only a few days, depending on the tide, ocean currents and setting conditions.<sup>22</sup>

### C. Pelagic Period

Polychaete eggs develop into free-swimming larvae (trochophores) which are provided with ciliated bands. (Fig. 8-A) Cilia is present in Glycera, but telescoped in Nereis virens. In the spherical egg, cleavage is equal for the first two divisions and then unequal.<sup>23</sup> The egg of Nereis is well supplied with yolk, but in Glycera yolk is almost lacking.<sup>20</sup> Slowly at first and then more rapidly the divisions occur until in the resulting blastula three germ-layers are differentiated. At this time the embryo begins to lose its spherical shape, and in time the cilia begin to grow out at the apex. The outside membrane or egg-membrane is the only protection which the larva has until the cilia appears. The part of the larva opposite the cilia now invaginates; a series of complicated divisions and movements occur internally, and the larva becomes the swimming trochophore. Coinciding with the trochophore stage is the pelagic stage which may last for weeks or days. Thus during gastrulation the embryonic worms rise to the surface where they are carried for considerable distances by the ocean tides. The trochophore stage is an important one because it enables the worms to become widely distributed. In this stage growth is the most important aspect. The embryos rapidly elongate; the anterior and posterior positions become clearly differentiated, and the body grows out from the postlateral bands and becomes segmented. The cilia which ring the embryo, and allow it to keep its pelagic position in the water, become confined to the head region as the worm grows out posteriorly, and the worm takes a vertical position in the water with the head region directed toward the surface. The forerunner of the super-oesophageal ganglion makes its appearance along with an eye spot in the head region; newly formed muscle fibers at the base of the ciliated band allow for the movement of the cilia. Other muscle masses elongate, and grow out posteriorly with the tail region, but before the tail begins to elongate, the trochophore has become bell-shaped on the upper surface and tapers conically on the under surface. (Fig. 8-A) Now,

however, by cell-proliferation resulting in segmentation proceeding from the anterior to the posterior, the embryo provides itself with a tail. (Fig. 8-B) The head region which has previously been huge in comparison with the rest of the body now becomes proportionately smaller, and the apical plate gives rise to cephalic processes and compound eyes. The later elongate stage of the pelagic period is more properly termed the polytroch, and the appearances of the larvae are now in most respects that of the adult worm. After the pelagic development is completed the worm leaves its surface existence and goes to the bottom where in the case of Nereis virens it burrows into the mud and builds a tube lined with its own mucus secretions. Glycera becomes a burrowing creature. This last period is called setting and is greatly influenced by the tides, types of sand and mud flats, and the degree of salinity of the water.<sup>23</sup>

#### NATURAL HISTORY

##### A. Food and Feeding

The food of all three species of worms consists almost entirely of seaweed (algae), although the clamworm is known also to feed on animal matter.<sup>24</sup> The reason that clamworms are sometimes found coiled inside dead clam shells is undoubtedly due to the worms' liking for the flesh of dead clams. The worms in no way are able to kill the clams which have a high natural death rate. The worm merely happens along, and takes advantage of the clam's dead or weakened condition (Copeland). Dr. Copeland's experiments with the clamworm show that it has a very keen chemical sense of food detection, and will respond to the most minute particles of ground clam meats.<sup>24</sup> Both the clamworm and bloodworm capture their prey and grasp their food by extending their proboscis in a quick movement and as quickly withdrawing it with the food clutched in their jaws. The action of the proboscis in withdrawing into the body cavity clamps the deep serrated teeth together in a vise-

like grip holding the food securely. While feeding the worms never leave their burrows. They wait until food swims or drifts past them, and only then constrict out of their tubes to gather in food. If danger threatens, or the food is too big or too active for them to capture, they immediately withdraw into the security of their tubes. Another use for the versatile proboscis is in tunneling through the mud. Extended rapidly and with much force it enables the worm to push aside the mud and make rapid progress. Unlike the common earthworm, Lumbricus, these worms do not draw the mud through their intestinal tract - the proboscis is extended closed when it is in use as a locomotion device.<sup>25</sup>

#### MORTALITY AND POPULATION: Present status

The nineteenth century has seen the addition of man to the long list of predatory enemies of Nereis and Glycera, and it is reasonable to suppose that locally man has now become the greatest single predator of the mature individuals. The greatest fatality that occurs during the life histories of these worms, however, occurs during the larval planktonic stage when the worms are extremely vulnerable to various voracious swimming organisms. Strong tidal actions undoubtedly destroy many of the larvae, and adverse setting conditions serve greatly to increase the mortality rate. Atoke mature individuals have few enemies other than man, but being cannibalistic they occasionally prey upon one another. Surface foraging atoke individuals and free-swimming members of the sexual epitoke stage fall prey to many species of fish, sea gulls and plovers. Flye believes that worm populations have been little depleted by commercial worming operations.<sup>4</sup> The depletion of some mud flats in or at the mouths of rivers may be due to the severe pollution that has affected many of our Maine rivers. Marine oil and gasoline from ships probably kill many of the planktonic larvae, but the effect on atoke populations has yet to be determined.



## SUMMARY AND RECOMMENDATIONS

1. Three commercially important Polychaete worms occur in large quantities in the mud and sand flats along the Maine coast. Two of them - Nereis virens and Glycera dibranchiata - are very widespread, but the third - Glycera americana - is of dubious distribution in Maine waters.
2. Nereis virens is a flat, iridescent and segmented marine worm having modified head and tail somites; and bordered laterally by two rows of paddle-like structures (parapoda) that are used for locomotive purposes. Glycera have a reddish color, smaller parapoda and are cylindrical rather than flat; tapering conically anteriorly and posteriorly. The Glycera have the head region less modified than Nereis virens, and the proboscis carries four curved teeth whereas there are only two in Nereis. Glycera dibranchiata and Glycera americana may be distinguished from each other by the different kinds of branchiae found on the parapoda. In Glycera americana the parapoda are retractile while in Glycera dibranchiata this is not true.
3. Nereis virens may grow to a length of thirty inches or more, but the usual size of adult atoke individuals is about nine and a half inches. Glycera average about eight inches and rare individuals may exceed twenty-five inches.
4. The usual habitat of Nereis virens is approximately at the high watermark in sand or mud-sand flats. Glycera is a more littoral species preferring the mud flats of river beds.
5. The breeding season for Nereis virens is in early spring while that of Glycera may last through the summer months. Nereis in the sexual period takes on an orange hue; Glycera becomes dulled. Both become flaccid.
6. The gonadal products are deposited freely in the sea when the ovum is fertilized. The fertilized egg develops into a pelagic trochophore. Later the larva goes to the bottom after it has been sufficiently developed.

7. Both Glycera and Nereis feed on algae, but the latter is also known to feed on animal material.

8. Plans of research should be undertaken as concern normal growth and development of Nereis virens and the two species of Glycera.

9. Attempts should be made to determine growth rates of adult worms as well as the larval stages. Large colonies under ideal conditions are difficult to attend and maintain; therefore, the artificial maintenance of larval and adult stages is a problem that must be thoughtfully worked out.

10. The feeding habits of larval and adult worms are still a problem especially of the former. Care should be taken to determine the food and frequency of feeding of both stages - especially in regard to growth rates.

11. The relationship of atoke and epitoke individuals along with the proportion of sexes is known rather sketchily. More observations should be made under controlled conditions to clarify the relationships.

12. The phenomena of mating in relation to temperature, etc., should be observed under controlled conditions.

13. Clam investigation techniques could be used to determine the best condition for larval setting.

14. Plankton samples should be taken during the breeding season to determine the numbers of free larvae and how far the pelagic larvae are carried by the tide before they set.

15. Soil analyses should be made to find out which areas provide for the greatest distributions and populations of Nereis virens and Glycera.

16. Water salinities should be taken in populated areas to determine how significant a part osmoregulation plays in the distribution of Glycera and Nereis.

17. Attempts should be made to determine the predators that exist, and in which stages the highest mortality rates occur.

18. Two other worms, Neanthes succinea and Platynereis dumerilii, are large enough to be used commercially and may perhaps be used to augment the supplies of other worms being dug.

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